Elements, Topology, and T-shirts

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Consider the network of elements connected by adjacency in atomic number and periodic table column. If all elements except H-He are connected by identical springs and constrained to a z-spiral in 2D, a map *sans* spring-crossing results for various values of rest length in units of the H-He distance. If the z-spiral is removed, and the network allowed to relax in 3D, the resulting surface with three holes has the topology of a T-shirt or open-handle teapot. Mapping this to a shirt's front-back pattern yields a 2D table of elemental inter-connects in tabular (nearly rectilinear) form. *Sample applications*: The flat spiral (like other spiral patterns) might serve as basis for an educational board game, while the T-shirt table might serve as a starting point for "topologically informed" classroom periodic-table design projects with wearable awards.

PACS numbers:

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I. INTRODUCTION

The traditional periodic table shows elemental columns nicely, but only intermittently shows element connectivity via adjacent proton number (e.g. Ne-Na or Ba-La). Hence a variety of "spiral" and "start-column" variations have emerged[1,2,3,4], involving designer decisions on where to put things. In this note, we explore ways to "let the elements decide" where to go, as if they are e.g. connected by a network of springs. This is a standard ploy for visualizing networks. The exploration also turned up an interesting topological connection between the periodic table and an item of everyday apparel.

II. SPRINGS ON A SPIRAL

Begin by considering elements as movable beads-on-a-track, connected with springs when they are adjacent in atomic number and/or in traditional periodic table column assignment. Our first reasonable pattern emerged with hydrogen, the noble gases, and elements heavier than xenon, fixed while letting the other elements slide along a spiral track under the influence of equal strength springs. Further letting the outer elements slide along the spring also worked, but only if one weakens a subset of the springs e.g. for atoms beyond Argon. Going back to equal strength springs, and allowing all elements except hydrogen and helium to go where they want on the wire, yields a slightly wilder layout but nonetheless without spring overlap for select values of "spring rest length" in units of the H-He distance.

The table form of this pattern, rotated to match the modern periodic table with noble gases on the right, is shown in Fig. 1. Given positions for hydrogen, helium (specifying scale and orientation) and lithium (specifying spring constant), all the other elements have decided where to go on their own. The patches for each element were then defined with an algorithm for locating intermediate vertices on spiral paths of the wire, and its 180 degree complement (which serves here to define the one continuous periodic table "row"). As you might expect, this table has fifty elements in eight long (6 or 7 entry) "main-element" columns on the lower right, forty elements in ten intermediate (4-entry) "transition-metal" columns, and twenty-eight elements in fourteen short (2-entry) "rare-earth" columns at the top.

III. RELAXING TO THREE DIMENSIONS

These connections between elements also rearrange themselves nicely under tension in three dimensions. In Fig. 2 we use Mathematica's spring-electrical model with adjacent element spring attraction, and a global "one over r-squared" repulsive force. In this screen capture from an interactive applet, note the black spiral pattern of increasing atomic number, as well as the three holes in the topographic sheet. These holes are associated with three network bifurcations, and in effect give the sheet the same topology as an open-handled teapot (top, spout, handle) or a T-shirt (neck opening and two sleeves).

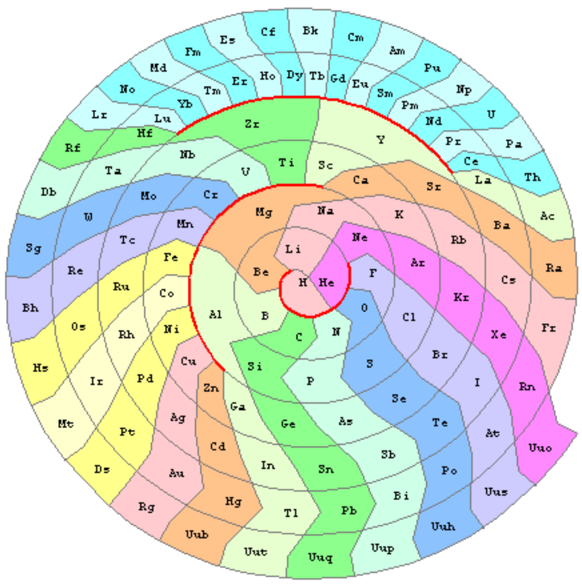

FIG. 1: Here the spring rest length is set at 2.5 times the fixed H-He distance.

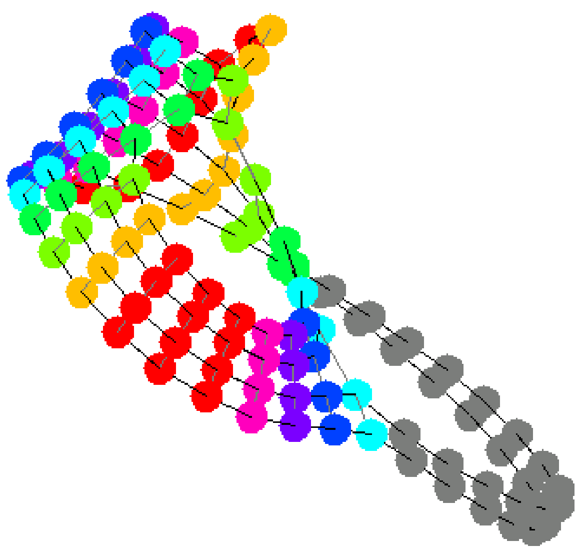

FIG. 2: This network is relaxed using Mathematica's spring-electrical model.

IV. T-SHIRT TABLE OF CONNECTIONS

The T-shirt topology suggests a way to display all connections in tabular (nearly rectilinear) form. Thus in Fig. 3 a black line charts the path of the atomic-number spiral, while all columns of elements flow from one of three red-bordered (bifurcation) openings. The main element groups pour in from the top, transition metal groups from the central opening, and rare earth groups from the bottom. One advantage to this format is that questions of period alignment[4] become mute since the z-spiral is shown intact in this layout (as well as on the T-shirt).

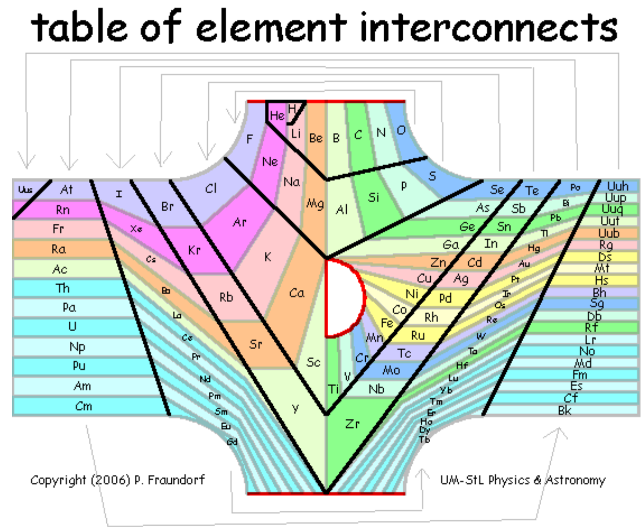

FIG. 3: Here the mapping to T-shirt topology is designed to make the layout as rectilinear as possible.

Although the topology of the connections above is dictated by quantum mechanics, the shape and color of each region leaves quite a bit of room for artistic license to address problems like that of flow, color balance, information content, and "crowding for the rare earths". In fact, one might imagine "periodic table shirt" design contests that honor the topological constraints, but go for a variety of effects (both aesthetic and conceptual). They might even work in a junior high school math class, making for a nicely cross-disciplinary experience. How to manufacture the contest prize, i.e. a shirt without obtrusive blank spots, remains an open question.

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